The New Hampshire Climate Change Policy Task Force

New Hampshire Climate Action Plan

A Plan for New Hampshire's Energy, Environmental and Economic Development Future

Appendix 7.1:

Residential, Commercial, and Industrial

Carbon Emissions and Economic Modeling: Approach and Assumptions

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Introduction

This document details the approach taken and the assumptions made in order to provide emissions and economic analyses of potential Actions proposed by the Working Groups and the Task Force. The results of the analyses are presented separately in the Analysis Results table. Detailed descriptions of the potential Actions are presented in the Action Reports produced by the Working Groups.

Total State Emissions Business-as-Usual Model:

The business-as-usual New Hampshire fossil fuel greenhouse gas emissions by sector were projected out to 2050 by extrapolating historical emissions data. Linear extrapolations of 1990-2005 emissions data[1] were used to project emissions in the Transportation, Residential, Commercial, and Industrial sectors. Emissions in the Electricity Generation sector were calculated differently because the historical New Hampshire emissions record is punctuated by large fluctuations due to the expansion and retirement of major generation plants. Linear extrapolation of total New England generation was extrapolated, and future New Hampshire generation was projected based on the assumption that New Hampshire will continue to contribute 17.3% of New England generation. Projected emissions were calculated based on the assumption that all future expansion of New Hampshire generation capacity is provided by natural gas plants.

Carbon Emissions Model:

Residential Model
The residential model uses Energy Information Administration (EIA) Fuel Use data[2] to characterize the total thermal and non-thermal energy use in NH residences, and the fuels profile used to satisfy those energy demands. Historical energy use data is used along with historical NH population data[3] to determine the average per capita energy intensity. Population growth projections[4] are multiplied by average per capita energy intensity to project future energy demand. For the business-as-usual (BAU) case, the total energy demand rises due to population growth while the fuel profile used to meet the energy demand remains constant.

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[1] EPA report: "Inventory of U.S. Greenhouse Gas Emissions and Sinks 1990-2006"
[2] Sources: Energy Information Administration, Residential Energy Consumption Surveys, 1978, 1979, 1980, 1981, 1982, 1984, 1987, 1990, 1993, 1997, and 2001.
[3] Historical population records: http://www.nh.gov/oep/programs/DataCenter/Population/90web.htm
[4] New Hampshire Office of Energy & Planning Population Projections Published - November 2006.

Current residences can be converted into 'renovated/refurbished' or 'new' residences, which are assigned separate thermal and non-thermal energy intensities and fuel profiles. All projected growth in housing due to population growth is considered 'new' residences. For the BAU case, no residences are renovated or refurbished, and all individual residences maintain the same energy intensities and fuel profiles.

Electricity emissions are calculated from a projection of the NE-ISO marginal emissions factor (Table 1). Fuel emissions are calculated using EIA fuel emissions factors (Table 2).

Note: direct emissions of natural gas due to leakage are not modeled.

Tables 3, 4 and 5 present values for selected parameters used for the Residential Model.

Table 1: Historical and projected values of the New England marginal emissions factor (projected values in *italics*)[5]

	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011-2050
NE Marginal emissions factor [lbs CO2/MWh]	1,488	1,394	1,338	1,179	1,102	1,107	*1,063*	*1,028*	*994*	*961*	*930*	*899*

Table 2: Residential fuel emissions factors[6]

	Fuel emissions factor [lbCO2e/million BTU]
Coal	225.130
Natural gas	117.080
Distillate fuel	161.386
Kerosene	159.535
LPG	139.039
Wood	0.000

Table 3: Population projection for NH[7]

	2000	2010	2020	2030	2040	2050
Population	1,247,342	1,356,521	1,465,700	1,574,879	1,684,058	1,793,237
Average annual growth		0.88%	0.80%	0.74%	0.69%	0.65%

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[5] Calculated from http://www.iso-ne.com/genrtion_resrcs/reports/emission/2005_mea_report.pdf
[6] http://www.eia.doe.gov/oiaf/1605/coefficients.html
[7] New Hampshire Office of Energy & Planning Population Projections Published - November 2006.

Table 4: Residential energy consumption and fuel profile[8]

Average annual thermal consumption [million BTU / person] =	40.1
Average annual non-thermal electric consumption [million BTU / person] =	8.7

Thermal fuel profile	
Electric	7.5%
Coal	0.0%
Natural gas	15.0%
Distillate fuel	52.3%
Kerosene	6.0%
LPG	14.2%
Wood	5.1%

Table 5: Other residential assumptions[9]

1,247,342	NH Population in 2000
474,517	Number of occupied housing units in NH in 2000
2.63	Average members per household in 2000
26%	of electricity is for thermal end use, historically

Commercial Model

The commercial model uses EIA Fuel Use data[10] to characterize the total thermal and non-thermal energy use in NH commercial buildings, and the fuels profile used to satisfy those energy demands. Commercial buildings classes include Education, Food Sales, Food Service, Health Care, Lodging, Mercantile, Office, Public Assembly, Public Order and Safety, Religious Worship, Service Warehouse and Storage as defined by EIA. Historical energy use data is used along with historical NH commercial building square footage data to determine the average per square foot energy intensity. Projections of commercial building floorspace growth projections are multiplied by average per square foot energy intensity to project future energy demand. For the business-as-usual (BAU) case, the total energy demand rises due to growth in commercial floorspace while the fuel profile used to meet the energy demand remains constant.

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[8] Calculated from: Energy Information Administration, Residential Energy Consumption Surveys, 1978, 1979, 1980, 1981, 1982, 1984, 1987, 1990, 1993, 1997, and 2001.

[9] Calculated from: Energy Information Administration, Residential Energy Consumption Surveys, 1978, 1979, 1980, 1981, 1982, 1984, 1987, 1990, 1993, 1997, and 2001 and New Hampshire Office of Energy & Planning Population Projections Published - November 2006.

[10] Energy Information Administration, Commercial Buildings Energy Consumption Surveys, 1992, 1995, 1999, and 2003.

Current commercial buildings can be converted into 'renovated/refurbished' or 'new' buildings, which are assigned separate thermal and non-thermal energy intensities and fuel profiles. All projected growth in commercial building floorspace is considered 'new' commercial floorspace. For the BAU case, no buildings are renovated or refurbished, and all buildings maintain the same energy intensities and fuel profiles.

Electricity emissions are calculated from a projection of the NE-ISO marginal emissions factor (Table 1). Fuel emissions are calculated using EIA fuel emissions factors (Table 6).

Note: direct emissions of natural gas due to leakage are not modeled.

Tables 7, 8, and 9 present values for selected parameters used for the Commercial Model.

Table 6: Commercial and Industrial fuel emissions factors[11]

	Emissions factor [lbCO2e/million BTU]
Coal	225.130
Natural gas	117.080
Distillate fuel	161.386
Kerosene	159.535
LPG	139.039
Motor gasoline	156.425
Residual fuel	173.906
Wood	0.000

Table 7: Commercial energy consumption and fuel profile[12]

Average annual thermal consumption [thousand BTU / sqft] =	94.2
Average annual non-thermal electric consumption [thousand BTU / sqft] =	30.0

Thermal fuel profile	
Thermal electric	14.0%
Coal	0.3%
Natural gas	29.4%
Distillate fuel	26.5%
Kerosene	1.2%
LPG	3.8%
Motor gasoline	0.3%
Residual fuel	23.3%
Biomass	1.2%

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[11] http://www.eia.doe.gov/oiaf/1605/coefficients.html
[12] Calculated from: Energy Information Administration, Commercial Buildings Energy Consumption Surveys, 1992, 1995, 1999, and 2003.

Table 8: Projections of number and floorspace of commercial buildings[13]

	2000	2010	2020	2030	2040	2050
Number of commercial buildings	19,902	24,736	29,571	34,405	39,240	44,074
Commercial floorspace [thousand sqft]	321,417	399,496	477,575	555,654	633,733	711,811

Table 9: Other commercial assumptions[14]

16,150   Average sqft per commercial building, New England [sqft]
8.8%   NH % of total New England Commercial Emissions

30.6%   of electricity is for thermal end use, historically

Industrial Model

The industrial model uses EIA Fuel Use data[15] to characterize the total energy use in NH industry, and the fuels profile used to satisfy those energy demands. Historical fuel use data do not show growth trends for energy use in the industrial sector. For the BAU case, the fuel profile used to meet the projected constant energy demand remains constant.

Industry can be converted into 'renovated/refurbished' or 'new' practices and buildings, which are assigned separate energy intensities and fuel profiles. For the BAU case, none of the industrial sector is renovated or refurbished, and the industrial sector maintains the same energy intensities and fuel profiles.

Electricity emissions are calculated from a projection of the NE-ISO marginal emissions factor (Table 1). Fuel emissions are calculated using EIA fuel emissions factors (Table 6).

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[13] Calculated from: Energy Information Administration, Commercial Buildings Energy Consumption Surveys, 1992, 1995, 1999, and 2003.
[14] Calculated from: Energy Information Administration, Commercial Buildings Energy Consumption Surveys, 1992, 1995, 1999, and 2003.
[15] http://www.eia.doe.gov/emeu/states/sep_use/ind/use_ind_nh.html

Emission Reduction Potential Calculation Assumptions

RCI Action 1.1 Maximize Energy Efficiency in New Construction
Efficiency gains of 30%, 70% and 100% (zero net energy) more efficient than BAU. The model assumes that 0.5% of the current building stock is turned over each year into 'new' buildings. Additionally, the number of buildings is projected to rise and all additional buildings are considered new buildings. In all three scenarios assume only 30% average improvement for the first 5 years, then 70% thereafter in 70% scenario, and 70% for next 5 yrs in 100% scenario, then 100% thereafter.[16]

RCI Action 1.2 Maximize Energy Efficiency in Existing Residential Buildings
Efficiency gains of 15, 30, and 60% for thermal and non-thermal energy at two phase-in rates: 15,000 homes/year and 30,000 homes/year.[17]

RCI Action 1.3 Maximize Energy Efficiency in Existing Commercial, Industrial and Municipal Buildings
Efficiency gains of 15, 30, and 50% for thermal and non-thermal energy. Total phase-in by 2030 is assumed. This corresponds to 1,100 commercial retrofits per year and retrofitting 4.7% of existing industrial annually.[18]

RCI Action 1.4A Upgrade Building Energy Codes
Discussion with Alliance to Save Energy indicated that compliance with the new 2006 Energy Code does not result in energy savings over old codes. Rather, the new code is easier to apply so it results in higher compliance rates (see Action 1.4B). A new code written from scratch could achieve any level of energy efficiency, so this action is modeled at 25% and 50% efficiency. Note that the energy code only applies to the thermal energy load, not the non-thermal electric load. Code is applied to new residential and commercial buildings. 0.5% annual old building turnover assumed.

RCI Action 1.4B Improve Building Energy Code Compliance
From discussion with Alliance to Save Energy: New homes that comply with the 2006 IECC are assumed to use 12% less heating and cooling energy than new homes that don't comply with any code. They assume 25% current compliance and set a target of 50% compliance. This means 25% more new buildings will be 12% more efficient than BAU, resulting in a 3% new building efficiency gain. For compliance target of 80%, new building efficiency gain is 6.6%. Note that the energy code only applies to the thermal energy load, not the non-thermal electric load. Code is applied to new residential and commercial buildings. 0.5% annual old building turnover assumed.

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[16] Efficiency levels and phase-in rate from RCI Working Group.
[17] Efficiency levels and phase-in rate from RCI Working Group.
[18] Efficiency levels and phase-in rate from RCI Working Group.

RCI Action 1.5 Establish an Energy Properties Section in MLS Listings
Action not individually quantified.

RCI Action 1.7 Preserve Older Buildings and Neighborhoods as Components of Sustainable Communities
Action not individually quantified.

RCI Action 1.8 Conserve Embodied Energy in Existing Building Stock
Action not individually quantified.

RCI Action 2.1 Create Incentive Programs to Install Higher Efficiency Equipment, Processes, and Systems
Action not individually quantified.

RCI Action 2.3 Require Annual CO2 Emissions Reporting
Action not individually quantified.

RCI Action 2.4 Develop Best-Practice Guidelines for Energy Efficient Process Equipment
Action not individually quantified.

RCI Action 2.5 Promote Net-Zero or Minimal-Emissions Industrial and Commercial Clusters
Action not individually quantified.

RCI Action 3.1   Promote Renewable Energy and Low-CO2e Thermal Energy Systems
Modeled as a renovation of 15,000 homes per year at 7% thermal efficiency gain. [19]

RCI Action 4.1 Include Energy Efficiency and Conservation in School Curriculum
Action not individually quantified.

RCI Action 4.2 Increase Energy Efficiency through Building Management Education Programs
Action not individually quantified.

RCI Action 4.3 Reduce Residential Energy Demand through Education and Outreach
Action not individually quantified.

RCI Action 4.4 Establish a Comprehensive Energy Efficiency and Renewable Energy Education Program
Action not individually quantified.

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[19] Efficiency levels and phase-in rate from RCI Working Group.

RCI Action 4.5 Create an Energy Efficiency and Sustainable Energy Systems Web Portal
Action not individually quantified.

Economic Model:

The CSNE economic modeling team took an "efficient analysis" approach to estimating the economic impacts of different actions proposed by the working groups, given the many different policy options considered. The modeling assumptions used in estimating economic costs and benefits are provided below.

The objective of the economic analysis was to estimate approximate "levels of magnitude" of the economic impacts of each proposed action item. Given the short time frame of analysis and large number of action items under consideration, this economic analysis is not as detailed as previous UNH economic studies of RPS and RGGI. It is instead meant to provide economic context to assist in the decision making process for the task force.

The analysis provided for the task force is limited to direct New Hampshire costs/benefits and does not include assessment of society wide impacts. As much as possible, direct employment impacts are estimated along with costs and benefits. The analysis does not consider potential benefits associated with actions such as reduced health costs due to reduced air pollution emissions and also does not include avoided costs in calculating economic impacts.

However where appropriate, an economic multiplier was used to estimate the broader state-wide economic impacts of cost savings, such as for reduced fuel consumption. An economic multiplier is used to estimate economy-wide impacts of specific economic changes. The UNH Economic team—based on its significant knowledge of the NH economy and to be conservative—chose a $1 economic multiplier for each $1 of savings attributed to an action. The assumptions section discusses whether the economic multiplier was applied to any given action. The 1:1 multiplier is considered conservative.[20]

The economic analysis does not discount costs and benefits of climate change policies to reflect timing or uncertainty. This is consistent with the approach used for NH RGGI and RPS analysis and used in the Stern Report. Ken Arrow, Nobel Laureate Economist, reviewed the Stern Report[21] and concluded that discounting for time and uncertainty did not change conclusions.[22]

In the analysis spreadsheet summarizing the carbon and economic impacts of each action item, levels of magnitude and qualitative information are provided, not precise figures for costs and

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[20] Federal Reserve Bank, 2002.
[21] Stern Review on the economics of climate change. 2006.
http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/stern_review_report.cfm
[22] "The case for cutting emissions," Ken Arrow, 2007.

benefits or the exact timing of those costs and benefits. The economic analysis section below provides an overview of the approach and assumptions use to model the economic costs and benefits of each action.

Implementation Costs
-   Low   0-$2.5 million
-   Moderately Low $2.5 million to $25
-   Moderate $25 million to $125 million
-   Moderately high $125 million to $500 million
-   High $500 million to $1 billion
-   Very high   Greater than $1 billion

-   Uncertain: Economic implementation costs were not easily determined without significant research beyond the scope of this part of the analysis.
-   Study: Means that the action proposed by the working group is a study to further look at issue, this is meant to avoid confusion in comparison of the costs of different actions.

Potential economic benefits
-   Low   0-$2.5 million
-   Moderately Low $2.5 million to $25
-   Moderate $25 million to $125 million
-   Moderately high $125 million to $500 million
-   High $500 million to $1 billion
-   Very high   Greater than $1 billion

-   Uncertain: Economic implementation costs were not easily determined without significant research beyond the scope of this part of the analysis.

Timing of Costs
-   Immediate/higher upfront: The majority of economic cost is experienced in the relative short term with the longer term economic cost being less significant
-   Constant/even: The economic cost tends to be relatively constant on an annual basis
-   Low short-term/Mostly long-term: The majority of economic cost is experienced in the relative long term with the shorter term economic cost being less significant
-   Uncertain: Economic implementation costs were not easily determined without significant research beyond the scope of this part of the analysis

Timing of Economic Benefits
-   Immediate/higher upfront: The majority of economic benefit is experienced in the relative short term with the longer term economic benefit being less significant
-   Constant/even: The economic benefit tends to be relatively constant on an annual basis

- Low short-term/Mostly long-term: The majority of economic benefit is experienced in the relative long term with the shorter term economic benefit being less significant
- Uncertain: Economic benefits were not easily determined without significant research beyond the scope of this part of the analysis

Who Experiences the Significant Portion of the Costs
- Consumer   (Evenly Distributed, Concentrated on particular groups)
- Government (State, Local)
- Business   (Evenly Distributed, Concentrated on particular groups)

Who Experiences the Significant Portion of the Benefits
- Consumer   (Evenly Distributed, Concentrated on particular groups)
- Government (State, Local)
- Business   (Evenly Distributed, Small, Medium, Large)

In the above, "Evenly distributed" means that costs and/or benefits are shared relatively equally across the respective group. "Concentrated on particular groups" means that costs and/or benefits are disproportionately borne by, for example, upper or lower income groups.

Economic analysis uses latest (2008) US-DOE EIA (Energy Information Administration) Energy Outlook in constant $2008. The EIA fuel forecast only goes out to 2030, the assumption was made that the 2030 price continues through 2050 in constant dollars. The only exception is the electricity price which was taken from the Independent Service Operator New England (ISO-NE) CELT (Capacity, Energy, Loads, and Transmission) forecast. The report projects prices specifically for NH out to 2017. The 2017 price was assumed to continue through 2050 in constant dollars.

If current prices are indicative the EIA forecasts are low, however the same fuel forecasts are applied consistently across all sectors for fuel savings. Therefore economic benefits based on fuel savings are appropriate as a comparative tool in the decision making process. It is also important to note that all dollars reported in the economic sections including fuel costs are in constant 2008 dollars. This allows for the reporting of costs and benefits in a dollar value in today's values.

CSNE Fuel Forecast ($2008)

	Units	2012	2025	2050
LPG	Gallon	$ 1.87	$1.89	$ 1.97
Residual Oil	Gallon	$ 1.48	$1.44	$ 1.57
Distillate Oil	Gallon	$ 2.59	$2.61	$ 2.78
Natural Gas	Therm	$ 0.87	$0.90	$ 0.99
Electricity- NH Specific	kWh	$ 0.15	$0.15	$ 0.15
Motor Gasoline	Gallon	$ 2.76	$2.71	$ 2.80
Diesel Fuel (distillate fuel oil)	Gallon	$ 2.75	$2.75	$ 2.91

Source: EIA Annual Energy Outlook for 2008

Economic Calculation Assumptions

RCI Action 1.1 Maximize Energy Efficiency in New Construction

Implementation costs were estimated on a housing unit basis for new residential construction and a square foot basis for commercial and industrial. Estimates of cost on new construction were not easily obtainable, as the construction costs can vary widely especially with commercial construction. Differential between new and existing construction for residential was roughly applied to "work backwards" from action 1.2 and 1.3 assumptions.[23]

Efficiency	Type	Cost	Unit
30%	Residential	$3,000	Residence
	Commercial	$2.5	SQ FT
	Industrial	$5	SQ FT
70%	Residential	$35,000	Residence
	Commercial	$14	SQ FT
	Industrial	$21	SQ FT
100%	Residential	$80,000	Residence
	Commercial	$90	SQ FT
	Industrial	$250	SQ FT

The 100% scenario was calculated by assuming cost of 100% solar PV and solar thermal to meet the electricity and thermal needs remaining after implementing energy efficiency meeting 50% of demand. Based on CSNE carbon model, Commercial was calculated to have an unmet need of 6 kWh per SQ FT for electricity and 13 kWh per SQ FT for thermal. Industrial was estimated

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[23] Based on assumptions from RCI Working Group.

to be 14 kWh per SQ FT for electricity and 50 kWh per SQ FT for thermal. At NH's latitude 1 kW of PV is assumed to produce 1000 kWh annually at an installed cost of $8000 ($2008); 1 kW of solar is also assumed to produce 1000 kWh of thermal annually at an installed cost of $2500 ($2008).[24]

Residential units and commercial square footage were taken from CSNE carbon analysis, industrial square footage was estimated by taking number of industrial electrical accounts in 2006 (3,100)[25] and multiplying average factory sq ft (25,000 sq ft)[26] to obtain ~ 77,000,000 sq ft of industrial.

Residential cost for 30% and 100% was based on assumptions provided by RCI working group. 70% residential was a linear interpolation based on these two other points. Implementation costs are installation and material costs only. Fuel savings were based on fuel consumption reductions calculated by CSNE carbon analysis. Also included in economic benefits is a $1 economic multiplier for each $1 saved from reduced fuel consumption.

	Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
	2012	2025	2050	2012	2025	2050
30%	$ 47	$ 46	$ 44	$ (130)	$ (547)	$ (1,355)
70%	$ 377	$ 369	$ 355	$ (279)	$ (1,215)	$ (3,035)
100%	$ 1,500	$ 1,471	$ 1,419	$ (393)	$ (1,736)	$ (4,336)

RCI Action 1.2 Maximize Energy Efficiency in Existing Residential Buildings
Assumed costs listed in table below.[27] Fuel savings were based on fuel consumption reductions calculated by CSNE carbon analysis. Also included in economic benefits is a $1 economic multiplier for each $1 saved from reduced fuel consumption.

Efficiency	Type	Cost	Unit
15%	15,000 Residential	$2,000	Residence
	30,000 Residential	$2,000	Residence
30%	15,000 Residential	$6,000	Residence
	30,000 Residential	$6,000	Residence
60%	15,000 Residential	$36,000	Residence
	30,000 Residential	$36,000	Residence

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[24] Photovoltaic Industry Statistics: Costs, Solarbuzz, Available online at http://www.solarbuzz.com/StatsCosts.htm Gallagher, Brian, Solar Thermal Energy in Delaware, Microsoft PowerPoint Presentation, Available online at http://www.seu-de.org/docs/Solar_Thermal_Presentation_Gallagher_3-06.pdf
[25] 2006 FERC Form 1 filing for PSNH, Unitil and National Grid
[26] Means Building Construction Cost Data 2008 Book, 66th Edition, RS Means, 2008
[27] Based on assumptions from RCI Working Group.

	Cost of Implementation (Annual $2008 Millions)			Cost Savings (Annual $2008 Millions)		
	2012	2025	2050	2012	2025	2050
30,000 homes/year; 15% more efficient	$ 60	$ 12	$ -	$ (106)	$ (434)	$ (448)
30,000 homes/year; 30% more efficient	$ 180	$ 37	$ -	$ (212)	$ (868)	$ (897)
30,000 homes/year; 60% more efficient	$ 1,080	$ 222	$ -	$ (425)	$ (1,735)	$ (1,793)
15,000 homes/year; 15% more efficient	$ 30	$ 30	$ -	$ (53)	$ (228)	$ (431)
15,000 homes/year; 30% more efficient	$ 90	$ 90	$ -	$ (106)	$ (455)	$ (863)
15,000 homes/year; 60% more efficient	$ 540	$ 540	$ -	$ (212)	$ (910)	$ (1,726)

RCI Action 1.3 Maximize Energy Efficiency in Existing Commercial, Industrial & Municipal Buildings

Assumed costs listed in table below; they were developed based on working group assumptions provided.[28] Fuel savings were based on fuel consumption reductions calculated by CSNE carbon analysis. Also included in economic benefits is a $1 economic multiplier for each $1 saved from reduced fuel consumption.

Efficiency	Type	Cost	Unit
15%	Commercial	$2	SQ FT
	Industrial	$4	Residence
30%	Commercial	$5	Residence
	Industrial	$10	Residence
50%	Commercial	$12	SQ FT
	Industrial	$20	SQ FT

	Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
	2012	2025	2050	2012	2025	2050
15%	$ 48	$ 42	$ 2	$ (93)	$ (365)	$ (486)
30%	$ 120	$ 106	$ 5	$ (156)	$ (730)	$ (972)
50%	$ 276	$ 247	$ 10	$ (240)	$ (1,216)	$ (1,620)

RCI Action 1.4A Upgrade Building Energy Codes

Utilized CSNE carbon analysis estimates of 25% and 50% for efficiency gains. Assumed compliance costs for stricter code would be the same as for existing code, therefore no marginal cost difference due to compliance costs. Utilized costs for new construction from assumptions for Action 1.1. To be consistent with CSNE carbon analysis only applied to new construction. Economic team was not comfortable with changing costs at these efficiency

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[28] Based on assumptions from RCI Working Group.

levels, even though electrical load was excluded in CSNE carbon analysis. Fuel savings were based on fuel consumption reductions calculated by CSNE carbon analysis. Also included in economic benefits is a $1 economic multiplier for each $1 saved from reduced fuel consumption.

	Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
	2012	2025	2050	2012	2025	2050
25% more efficient thermal	$ 39	$ 38	$ 36	$ (108)	$ (455)	$ (1,129)
50% more efficient thermal	$ 269	$ 264	$ 254	$ (199)	$ (868)	$ (2,168)

RCI Action 1.4B Improve Building Energy Code Compliance
Rough estimate of number of building code inspectors was developed with a range of 90-260. This is based on looking at the number of inspectors in different towns and cities in NH. It was found that there is 1 inspector for Barrington, NH with population of ~8,000, 6 inspectors for Nashua, NH with population of ~87,000 , and 4 inspectors in Portsmouth, NH with a population of ~20,000. Multiplying ratio of inspectors to town or city populations was extrapolated out to the entire NH population of 1.3 million. Assumed 260 building inspectors for this analysis. Assumed first year cost of $2000 for initial training and $1000 for annual training (based on informal review of professional training courses).   To be consistent with CSNE carbon analysis only applied to new construction. Fuel savings were based on fuel consumption reductions calculated by CSNE carbon analysis. Also included in economic benefits is a $1 economic multiplier for each $1 saved from reduced fuel consumption.

	Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
	2012	2025	2050	2012	2025	2050
50% compliance (3% more efficient thermal)	$ 0.1	$ 0.1	$ 0.1	$ (8)	$ (32)	$ (81)
80% compliance (6.6% more efficient thermal)	$ 0.1	$ 0.1	$ 0.1	$ (15)	$ (64)	$ (162)

RCI Action 1.5 Establish an Energy Properties Section in MLS Listings

Assumed an incremental cost of $20 per listing that would be necessary for a MLS listing. Cost of home energy audit assumed to be $200 determined by quick web review and conversation with home energy auditors.[29] Total cost estimated at $220 per listing. Annual number of listings for existing home sales estimated to be 20,000, based on existing home sales for NH from Realtor.org for 2008[30], new homes derived from CSNE carbon calculations (approximately 6,200 per year). Total annual listings estimated at 27,000 for a recurring annual cost of ~$6 million. Supporting mechanism for residential energy efficiency.

RCI Action 1.7 Preserve Older Buildings and Neighborhoods as Components of Sustainable Communities

Assumed a cost of $200,000 for administrative costs.[31] Supporting mechanism for residential energy efficiency.

RCI Action 1.8 Conserve the Embodied Energy in Existing Building Stock

Average construction cost of new residential assumed to be $115 per SQ FT based.[32] The average size is 2,500 square feet based on 2005 RECS. Material assumed to be 50% of household cost.[33] There was an assumed 5% salvage rate of materials.[34] This was calculated to be a savings of $7,000 in building materials. Utilize Action 1.2 30,000 homes at 30% efficiency to calculate implementation costs.[35] Also included in economic benefits is a $1 economic multiplier for each $1 saved from reduced fuel consumption.

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	2025	2050	2012	2025	2050
$ 180	$ 37	$ -	$ (373)	$ (1,029)	$ (897)

RCI Action 2.1 Create Incentive Programs to Install Higher Efficiency Equipment, Processes, and Systems

Core programs currently match approximately 50% of cost. Action 1.1 (25%), Action 1.2 (30,000 homes at 30%) and Action 1.3 (30%) were combined to calculate a total implementation cost, as these are believed to be reasonable targets based on EE research (NEEP). 50% of this figure was then taken to estimate magnitude of funds required through public programs. Supporting mechanism for residential energy efficiency.

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[29] Active Rain Real Estate Network, Available online at http://activerain.com/energydoctor and conversation in Summer 2008 with NH based A+ Energy Auditor.

[30] Metropolitan Median Prices, National Association of Realtors, Available online at http://www.realtor.org/research/research/metroprice

[31] Assumption by UNH Economic team based on policy description

[32] Means Building Square Foot Cost Data 2008 Book,, RS Means, 2008

[33] Building Cost.Net Online Calculator, Available online at http://www.building-cost.net/

[34] Based on assumptions from RCI Working Group.

[35] UNH Economic team assumption based on RCI working group description

Cost of Implementation (Annual $2008 Millions)		
2012	2025	2050
$ 173	$ 94	$ 24

RCI Action 2.3 Require Annual CO2 Emissions Reporting

Greenhouse gas inventory cost assumed to average $500.[36] Also assumed is 1 DES staff w/benefits at $60,000 to administering program.[37] This assumes industrial are required to file and that there is additional workload required to monitor. Only assumed to apply to the 3,100 industrial in NH (see action 1.1). A supporting mechanism for increased energy efficiency in buildings.

Cost of Implementation (Annual $2008 Millions)		
2012	2025	2050
$ 2	$ 2	$ 2

RCI Action 2.4 Develop Best-Practice Guidelines for Energy Efficient Process Equipment

Assumed 1 government staff w/benefits at $60,000 each devoted full-time to administering program and $40,000 annual marketing budget annually recurring.[38] Supporting mechanism for increased energy efficiency in buildings.

RCI Action 2.5 Promote Net-Zero or Minimal Emissions Industrial and Commercial Clusters

Assumed construction of 25,000 square foot commercial in 2012 as demonstration project at $75/sq ft[39] plus the additional cost of new construction $90/sq ft(100% EE New Commercial – see Action 1.1) for a total of $165 total per sq ft. Total beta site cost estimated at $4.2 million. Supporting mechanism for increased energy efficiency in buildings.

RCI Action 3.1   Promote Renewable Energy and Low-CO2e Thermal Energy Systems

Several different funding mechanisms were listed, including a thermal benefit charge. This analysis assumes the $3 per watt incentive proposed in HB 1628. A 2 KW average system for residential was assumed,[40] which calculates to a $6,000 incentive for solar thermal per household (see action 1.1). This works out to a 7 MMBTU per house hold reduction or a 7% thermal efficiency gain based on CSNE carbon model. An assumed adoption rate of 15,000 existing houses per year was also assumed.[41] Also included in economic benefits is a $1 economic multiplier for each $1 saved from reduced fuel consumption.

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[36] Based on UNH economic team's experience on effort involved in calculating for small, medium and large sized businesses

[37] UNH Economic team assumption

[38] UNH Economic team assumption

[39] Means Building Construction Cost Data 2008 Book, 66th Edition, RS Means, 2008

[40] Solar Thermal Energy, SWB Energie und Wasser, Available online at http://www.swb.bonn.de/Solar_Thermal_Energy.544.0.html

[41] Assumption by UNH Economic Team

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	2025	2050	2012	2025	2050
$ 90	$ 90	$ -	$ (16)	$ (69)	$ (134)

RCI Action 4.1 Include Energy Efficiency and Conservation in School Curriculum
Assumed 5 annual training workshops for teachers at a cost of $5,000 per workshop. Plus 1 full time benefited government employee to administer program at $60,000 per year.[42] Supporting mechanism for increased energy efficiency in buildings.

RCI Action 4.2 Increase Energy Efficiency through Building Management Education Programs
Cost assumed to be $2000 per year for building managers and $25 per person for residential.[43] Fuel savings based on estimate of 0.5 kWh savings per square foot (assumed to be 5% of electrical for residential, commercial and industrial) and 2 MMBTU of thermal load per 1,000 sq ft (assumed to be to be 5% of thermal for residential, commercial and industrial.)[44] Applied to all new commercial, and residential. Existing homes at a rate of 15,000 per year, commercial at 1,100 and all 3,100 industrial per year. Also included in economic benefits is a $1 economic multiplier for each $1 saved from reduced fuel consumption.

Cost of Implementation (Annual $2008 Millions)			Economic Benefits (Annual $2008 Millions)		
2012	2025	2050	2012	2025	2050
$ 10	$ 4	$ 1	$ (55)	$ (231)	$ (414)

RCI Action 4.3 Reduce Residential Energy Demand through Education and Outreach
Assumed a $200,000 annual grant to sustain the NH Carbon Challenge program.[45] Supporting mechanism for increased energy efficiency in buildings.

RCI Action 4.4 Establish a Comprehensive Energy Efficiency and Renewable Energy Education Program
Similar to Action 4.2

RCI Action 4.5 Create an Energy Efficiency and Sustainable Energy Systems Web Portal
Very similar to action 4.3, upfront investment of $100,000 and $20,000 annual maintenance assumed for web portal.[46] Supporting mechanism for increased energy efficiency in buildings.

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[42] Assumption by UNH Economic Team
[43] Assumption by UNH Economic Team
[44] Assumption by RCI Working Group
[45] Assumption by UNH Economic Team
[46] Assumption by UNH Economic Team